JEE (Main) PHYSICS SOLVED PAPER

2023
25th Jan Shift 1

Section A

Q. 1. Match List I with list II

List I	List II
A. Surface tension	I. $kgm^{-1}s^{-1}$
B. Pressure	II. $kgms^{-1}$
C. Viscosity	III. $kgm^{-1}s^{-2}$
D. Impulse	IV. kgs^{-2}

Choose the correct answer from the options given below:

(1) A-II, B-I, C-III, D-IV **(2)** A-IV, B-III, C-I, D-II
(3) A-III, B-IV, C-I, D-II **(4)** A-IV, B-III, C-II, D-I

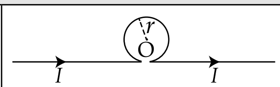
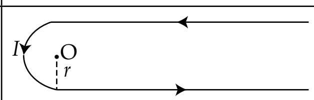
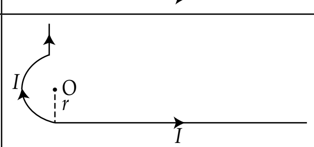
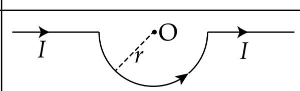
Q. 2. The ratio of the density of oxygen nucleus ($^{16}_{8}O$) and helium nucleus ($^{4}_{2}He$) is:

(1) 4 : 1 **(2)** 2 : 1 **(3)** 1 : 1 **(4)** 8 : 1

Q. 3. The root mean square velocity of molecules of gas is

(1) Inversely proportional to square root of temperature $\left(\sqrt{\frac{1}{T}}\right)$
(2) Proportional to square of temperature (T^2)
(3) Proportional to temperature (T)
(4) Proportional to square root of temperature ($\sqrt{T}$)

Q. 4. Match List I with II

List (Current configuration)		List II (Magnitude of Magnetic Field at point O)
A.		I. $B_0 = \frac{\mu_0 I}{4\pi r}[\pi + 2]$
B.		II. $B_0 = \frac{\mu_0}{4}\frac{I}{r}$
C.		III. $B_0 = \frac{\mu_0 I}{2\pi r}[\pi - 1]$
D.		IV. $B_0 = \frac{\mu_0 I}{4\pi r}[\pi + 1]$

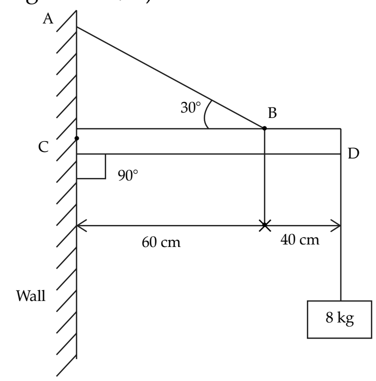
Choose the correct answer from the options given below:

(1) A-III, B-I, C-IV, D-II **(2)** A-I, B-III, C-IV, D-II
(3) A-III, B-IV, C-I, D-II **(4)** A-II, B-I, C-IV, D-III

Q. 5. A message signal of frequency 5 kHz is used to modulate a carrier signal of frequency 2 MHz. The bandwidth for amplitude modulation is:

(1) 20 kHz **(2)** 5 kHz **(3)** 10 kHz **(4)** 2.5 kHz

Q. 6. An object of mass 8 kg hanging from one end of a uniform rod CD of mass 2 kg and length 1 m pivoted at its end C on a vertical wall as shown in figure. It is supported by a cable AB such that the system is in equilibrium. The tension in the cable is: (Take g = 10 m/s^2)



(1) 90 N **(2)** 30 N **(3)** 300 N **(4)** 240 N

Q. 7. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R

Assertion A: Photodiodes are used in forward bias usually for measuring the light intensity.

Reason R: For a *p-n* junction diode, at applied voltage V the current in the forward bias is more than the current in the reverse bias for $|V_Z| > \pm V \geq |V_0|$ where V_0 is the threshold voltage and V_z is the breakdown voltage.

In the light of the above statements, choose the correct answer from the options given below:

(1) Both A and R are true and R is correct explanation of A.
(2) A is false but R is true.
(3) Both A and R are true but R is NOT the correct explanation of A
(4) A is true but R is false

Q. 8. In an LC oscillator, if values of inductance and capacitance become twice and eight times, respectively, then the resonant frequency of oscillator becomes x times its initial resonant frequency ω_0 .The value of x is:

(1) 4 **(2)** $\frac{1}{16}$ **(3)** 16 **(4)** $\frac{1}{4}$

Q. 9. A uniform metallic wire carries a current 2 A, when 3.4 V battery is connected across it. The mass of uniform metallic wires is 8.92×10^{-3} kg density is 8.92×10^3 kg/m^3 and resistivity is 1.7×10^{-8} Ω m. The length of wire is:

(1) l = 10 m **(2)** l = 100 m
(3) l = 5 m **(4)** l = 6.8 m

Q. 10. A car travels a distance of 'x' with speed v_1 and then same distance 'x' with speed v_2 in the same direction. The average speed of the car is:

(1) $\frac{2v_1v_2}{v_1+v_2}$ (2) $\frac{2x}{v_1+v_2}$

(3) $\frac{v_1v_2}{2(v_1+v_2)}$ (4) $\frac{v_1+v_2}{2}$

Q. 11. A car is moving with a constant speed of 20 m/s in a circular horizontal track of radius 40 m. A bob is suspended from the roof of the car by a massless string. The angle made by the string with the vertical will be: (Take g = 10 m/s^2)

(1) $\frac{\pi}{3}$ (2) $\frac{\pi}{2}$ (3) $\frac{\pi}{4}$ (4) $\frac{\pi}{6}$

Q. 12. A bowl filled with very hot soup cools from 98°C to 86°C in 2 minutes when the room temperature is 22°C. How long it will take to cool from 75°C to 69°C?

(1) 1 minute (2) 1.4 minutes

(3) 0.5 minute (4) 2 minutes

Q. 13. A solenoid of 1200 turns is wound uniformly in a single layer on a glass tube 2 m long and 0.2 m in diameter. The magnetic intensity at the center of the solenoid when a current of 2 A flows through it is?

(1) 2.4×10^3 A m^{-1} (2) 1.2×10^3 A m^{-1}

(3) 2.4×10^{-3} A m^{-1} (4) 1 A m^{-1}

Q. 14. In Young's double slits experiment, the position of 5th bright fringe from the central maximum is 5 cm. The distance between slits and screen is 1 m and wavelength of used monochromatic light is 600 nm. The separation between the slits is:

(1) 48 μm (2) 36 μm

(3) 12 μm (4) 60 μm

Q. 15. An electromagnetic wave is transporting energy in the negative z direction. At a certain point and certain time the direction of electric field of the wave is along positive y direction. What will be the direction of the magnetic field of the wave at the point and instant?

(1) Negative direction of y
(2) Positive direction of z
(3) Positive direction of x
(4) Negative direction of x

Q. 16. A parallel plate capacitor has plate area 40 cm^2 and plates separation 2 mm. The space between the plates is filled with a dielectric medium of a thickness 1 mm and dielectric constant 5. The capacitance of the system is:

(1) $24\varepsilon_0$F (2) $\frac{10}{3}\varepsilon_0$F (3) $\frac{3}{10}\varepsilon_0$F (4) $10\varepsilon_0$F

Q. 17. Assume that the earth is a solid sphere of uniform density and a tunnel is dug along its diameter throughout the earth. It is found that when a particle is released in this tunnel, it executes a simple harmonic motion. The mass of the particle is 100 g. The time period of the motion of the particle will be (approximately) (Take g = 10 m s^{-2}, radius of earth = 6400 km)

(1) 12 hours (2) 1 hour 40 minutes

(3) 24 hours (4) 1 hour 24 minutes

Q. 18. Electron beam used in an electron microscope, when accelerated by a voltage of 20 kV, has a de-Broglie wavelength of λ_0. If the voltage is increased to 40 kV, then the de-Broglie wavelength associated with the electron beam would be:

(1) $3\lambda_0$ (2) $\frac{\lambda_0}{2}$ (3) $\frac{\lambda_0}{\sqrt{2}}$ (4) $9\lambda_0$

Q. 19. A Carnot engine with efficiency 50% takes heat from a source at 600 K. In order to increase the efficiency to 70%, keeping the temperature of sink same, the new temperature of the source will be:

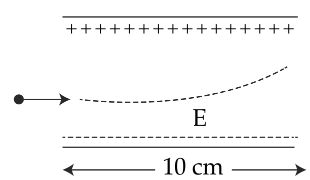
(1) 300 K (2) 900 K (3) 1000 K (4) 360 K

Q. 20. T is the time period of simple pendulum on the earth's surface. Its time period becomes xT when taken to a height R (equal to earth's radius) above the earth's surface. Then, the value of x will be:

(1) 4 (2) 2 (3) $\frac{1}{4}$ (4) $\frac{1}{2}$

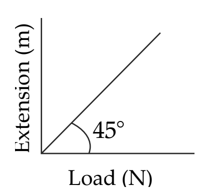
Section B

Q. 21. A uniform electric field of 10 N/C is created between two parallel charged plates (as shown in figure). An electron enters the field symmetrically between the plates with a kinetic energy 0.5 eV. The length of each pate is 10 cm. The angle (θ) of deviation of the path of electron as it comes out of the field is ______ (in degree).



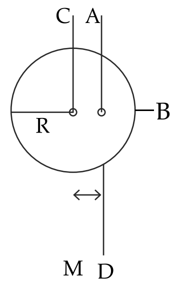
Q. 22. The wavelength of the radiation emitted is λ_0 when an electron jumps from the second excited state to the first excited state of hydrogen atom. If the electron jumps from the third excited state to the second orbit of the hydrogen atom, the wavelength of the radiation emitted will be $\frac{20}{x}\lambda_o$. The value of x is _______.

Q. 23. As shown in the figure, in an experiment to determine Young's modulus of a wire, the extension-load curve is plotted. The curve is a straight line passing through the origin and makes an angle of 45° with the load axis. The length of wire is 62.8 cm and its diameter is 4 mm. The Young's modulus is found to be $x \times 10^4$ Nm^{-2}. The value of x is _________.

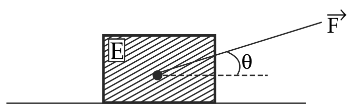


Q. 24. I_{CM} is the moment of inertia of a circular disc about an axis (CM) passing through its center and perpendicular to the plane of disc. I_{AB} is moment of inertia about an axis AB perpendicular to plane and parallel to axis CM at a distance $\frac{2}{3}R$ from center.

Where R is the radius of the disc. The ratio of I_{AB} and I_{CM} is $x : 9$ The value of x is __________.



Q. 25. An object of mass 'm' initially at rest on a smooth horizontal plane starts moving under the action of force F = 2N. In the process of its linear motion, the angle θ (as shown in figure) between the direction of force and horizontal varies as $\theta = kx$, where k is constant and x is the distance covered by the object from the initial positon. The expression of kinetic energy of the object will be $E = \frac{n}{k}\sin\theta$, The value of n is ______.

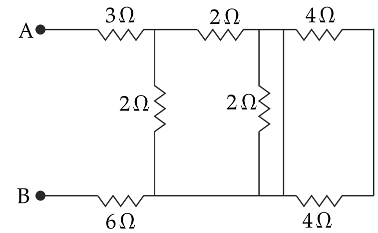


Smooth horizontal surface

Q. 26. An LCR series circuit of capacitance 62.5 nF and resistance of 50 Ω, is connected to an A.C. source of frequency 2.0 kHz. For maximum value of amplitude of current in circuit, the value of inductance is _______ mH. (Take $\pi^2 = 10$)

Q. 27. The distance between two consecutive points with phase difference of 60° in a wave of frequency 500 Hz is 6.0 m. The velocity with which wave is traveling is ___________ km/s.

Q. 28. In the given circuit, the equivalent resistance between the terminal A and B is Ω.



Q. 29. If $\vec{P} = 3\hat{i} + \sqrt{3}\hat{j} + 2\hat{k}$ and $\vec{P} = 4\hat{i} + \sqrt{3}\hat{j} + 2.5\hat{k}$ then, The unit vector in the direction of $\vec{P} \times \vec{Q}$ is $\frac{1}{x}\left(\sqrt{3}\hat{i} + \hat{j} - 2\sqrt{3}\hat{k}\right)$. The value of x is.

Q. 30. A ray of light is incident from air on a glass plate having thickness $\sqrt{3}$ cm and refractive index $\sqrt{2}$. The angle of incidence of the ray is equal to the critical angle for glass-air interface. The lateral displacement of the ray when it passes through the plate is ______ $\times 10^{-2}$ cm. (given sin 15° = 0.26)

Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	(2)	Units	Units and Dimensions
2	(3)	Nucleus Density	Nuclei
3	(4)	RMS Velocity of Gas	Kinetic Theory of Gases
4	(1)	Magnetic Field due to a Currnet Carrying Straight Wire	Moving Charges and Magnetism
5	(3)	Amplitude Modulation	Communication Systems
6	(3)	Tension in a String	Laws of Motion
7	(2)	Photodiode	Semiconductor Electronics
8	(4)	Resonance Frequency	Alternating Current
9	(1)	Resistivity	Current Electricity
10	(1)	Average Speed	Motion in a Straight Line
11	(3)	Tension in a String	Laws of Motion
12	(2)	Newton's Law of Cooling	Thermal Properties of Matter
13	(2)	Solenoid	Magnetism and Matter
14	(4)	Young's Double Slit Experiment	Wave Optics
15	(3)	Propagation of EMW	Electromagnetic Waves
16	(2)	Parallel Plate Capacitor	Electrostatic Potential and Capacitance

17	(4)	SHM	Oscillations and Waves
18	(3)	Photoelectric Effect	Dual Nature of Radiation and Matter
19	(3)	Carnot Engine	Thermodynamics
20	(2)	Variation in Acceleration due to Gravity	Gravitation
21	[45]	Electric Field	Electric Charges and Fields
22	[27]	Atomic Spectrum	Atoms
23	[5]	Young's Modulus of Elasticity	Mechanical Properties of Solids
24	[17]	Moment of Inertia	System of Particles and Rotational Motion
25	[2]	Work	Work, Energy and Power
26	[100]	Resonance Frequency	Alternating Current
27	[18]	Propagation of Waves	Oscillations and Waves
28	[10]	Electric Circuit	Current Electricity
29	[4]	Vectors	Motion in a Plane
30	[52]	Refraction Through a Glass Slab	Ray Optics

SOLUTIONS

Section A

1. Option (2) is correct.

Surface tension $= \frac{F}{l} = \frac{ma}{l}$ (kg s^{-2})

Pressure $= \frac{F}{A} = \frac{ma}{A}$ (kg m^{-1}s^{-2})

Viscosity $= \frac{F}{A\left(\frac{dv}{dy}\right)}$ (kg m^{-1}s^{-1})

Impulse $= Ft = (ma)t$ (kg ms^{-1})

2. Option (3) is correct.

Density of a nucleus remains constant, Independent of the mass number of the nucleus.

$$\rho = 2.3 \times 10^{17} \text{ kgm}^{-3}$$

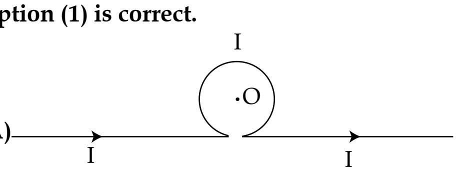
3. Option (4) is correct.

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

For a given gas, $v_{rms} \propto \sqrt{T}$

4. Option (1) is correct.

(A)

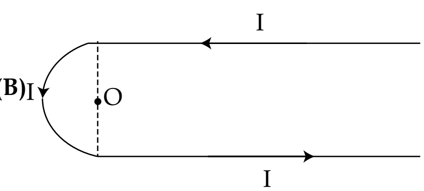


$$\vec{B}_0 = \vec{B}_1 + \vec{B}_2$$

$$= \frac{\mu_0 I}{2\pi r} \odot + \frac{\mu_0 I}{2r} \otimes$$

$$|\vec{B}_0| = \frac{\mu_0 I}{2\pi r}(\pi - 1)$$

(B)

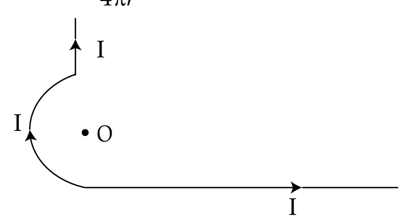


$$\vec{B}_0 = \vec{B}_1 + \vec{B}_2 + \vec{B}_3$$

$$= \frac{\mu_0 I}{4\pi r} \odot + \frac{\mu_0 I}{4r} \odot + \frac{\mu_0 I}{4\pi r} \odot$$

$$|\vec{B}_0| = \frac{\mu_0 I}{4\pi r}(\pi + 2)$$

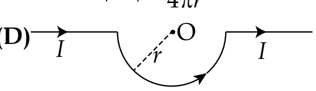
(C)



$$\vec{B}_0 = \vec{B}_1 + \vec{B}_2 + \vec{B}_3 = 0 + \frac{\mu_0 I}{4r} \otimes + \frac{\mu_0 I}{4\pi r} \otimes$$

$$|\vec{B}_0| = \frac{\mu_0 I}{4\pi r}(\pi + 1)$$

(D)



$$\vec{B}_0 = \vec{B}_1 + \vec{B}_2 + \vec{B}_3 = 0 + \frac{\mu_0 I}{4r} \odot + 0$$

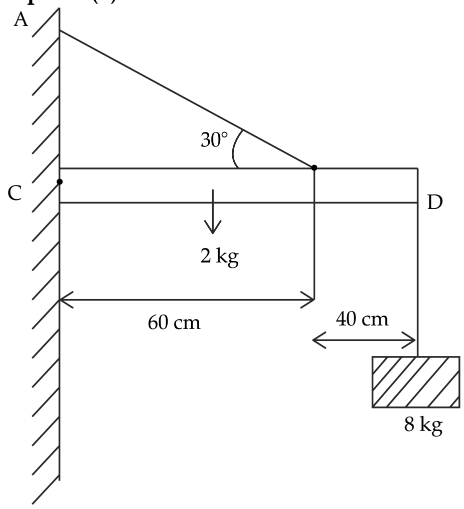
$$|\vec{B}_0| = \frac{\mu_0 I}{4r}$$

5. Option (3) is correct.

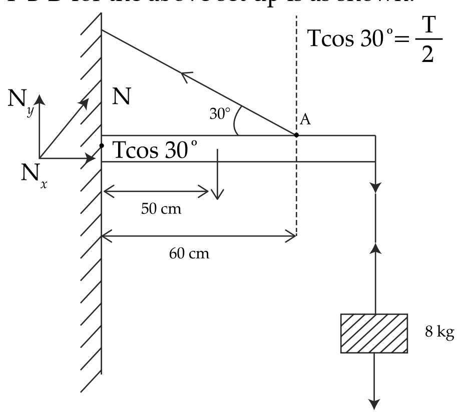
For amplitude modulation (AM), bandwidth is given by 2 fm where fm is the signal (basez band).

Hence, 2 fm = 2 × 5 = 10 kHz

6. Option (3) is correct.



F B D for the above set up is as shown:



For equilibrium of the rod

$\sum F_x = 0 \rightarrow N_x = T\cos 30^o = T\frac{\sqrt{3}}{2}$

Where N is the normal reaction exerted on the rod by the wall and $N = \sqrt{N_x^2 + N_y{}^2}$

Also $T_1 = 8g$

$$\sum F_y = 0 \rightarrow T_1 + 2\,g = \left(T\sin 30° = \frac{T}{2}\right) + N_y$$

$$8g + 2g = \frac{T}{2} + N_y$$

For rotational equilibrium, net torque about any Point = 0

$$\Sigma T_s = 0$$

$$2g(0.5) + 8g(1) = (T\sin 30^0)(0.6)$$

$$10 + 80 = 0.3T$$

$$T = \frac{90}{0.3} = 300 \text{ Newton}$$

7. Option (2) is correct.

Photodiodes always operate in the reverse bias mode. Assertion (A) is false.

For a normal p-n junction diode, current in the forward bias mode is always greater than that in the reverse bias mode. Reason (R) is true.

8. Option (4) is correct.

For an LC oscillator, $\omega_0 = \frac{1}{\sqrt{LC}}$

IF $L' = 2L$ and $C' = 8C$

$$\omega_0' = \frac{1}{\sqrt{16LC}} = \frac{\omega_0}{4} = x\omega_0$$

On comparing we get $x = \frac{1}{4}$.

9. Option (1) is correct.

$$R = \frac{V}{I} = \rho\frac{l}{A} \quad \text{...(i)}$$

$$M = \text{Volume} \times \text{density}$$
$$= (Al)\rho d$$

$$Ad = \frac{M}{l\rho_d}$$

Putting for A in eq (i),

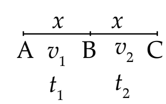
$$\frac{V}{I} = \rho\left(\frac{\rho_d}{M}\right)$$

$$l^2 = \frac{V}{I}\frac{M}{\rho\,\rho_d} = \frac{3.4}{2} \times \frac{8.92 \times 10^{-3}}{1.7 \times 10^{-8} \times 8.92 \times 10^3}$$

$$l^2 = 100$$

$$l = 10 \text{ m}$$

10. Option (1) is correct.

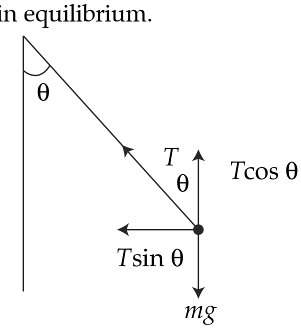


$$\text{Average speed} = \frac{\text{total distance}}{\text{total time}} = \frac{2x}{t_1 + t_2}$$

$$= \frac{2x}{\frac{x}{v_1} + \frac{x}{v_2}} = \frac{2v_1 + v_2}{v_1 + v_2}$$

11. Option (3) is correct.

Let the string of the pendulum makes an angle θ with the vertical in the frame of reference of car $\sum \vec{F} = 0$ as Pendulum is in equilibrium.



$$T\cos\theta = mg \quad \text{....(i)}$$

$$T\sin\theta = m\frac{v^2}{R} \text{ (centrifugal force)} \quad \text{....(ii)}$$

Dividing equation (ii) by (i)

$$\tan\theta = \frac{v^2}{Rg} = \frac{20 \times 26}{40 \times 10} = 1$$

$$\theta = \frac{\pi}{4}$$

12. Option (2) is correct.

Applying Newton's law of cooling

$$\frac{\Delta T}{\Delta t} = \beta(T_{av} - T_0)$$

where, β is a constant and T_0 = surrounding temperature.

$$\frac{98-86}{2} = \beta\left(\frac{98+86}{2} - 22\right)$$

$$6 = \beta(70) \quad \text{...(i)}$$

$$\frac{75-69}{t} = \beta\left(\frac{75+69}{2} - 22\right)$$

$$\frac{6}{t} = \beta(50) \quad \text{...(ii)}$$

Dividing equation (i) by (ii), we get

$$t = \frac{7}{5} = 1.4 \text{ min}$$

13. Option (2) is correct.

Magnetic field inside a solenoid, $B = \mu_0 ni$

$$n = \frac{N}{l}$$

$$B = \frac{\mu o N i}{l} = \frac{4\pi\times10^{-7}\times1200\times2}{2} = 48\pi\times10^{-5}\,\text{T}$$

Magnetic intensity, $H = \frac{B}{\mu_0} = \frac{48\pi\times10^{-5}}{4\pi\times10^{-7}}$

$$= 12 \times 10^2$$

$$= 1.2 \times 10^3 \text{ A/m}$$

14. Option (4) is correct.

Position of n^{th} bright fringe in YDSE

$$y_n = \frac{D}{d}(n\lambda)$$

$$5\times10^{-2} = \frac{1\times5\times600\times10^{-9}}{d}$$

$$d = \frac{3\times10^{-6}}{5\times10^{-2}} = 06\times10^{-4}$$

15. Option (3) is correct.

For an electromagnetic wave the directions of $\vec{E}$, $\vec{B}$ and $\vec{C}$ are related by

$$\vec{E}\times\vec{B} = \vec{C}$$

$$\hat{i}\times\vec{b} = -\hat{k}$$

since $\hat{i}\times\hat{l} = -\hat{k}$

$\vec{B}$ is directed along positive x direction.

16. Option (2) is correct.

For a partially filled dielectric of thickness t

$$C = \frac{\varepsilon_0 A}{d - t\left(1-\frac{1}{K}\right)}$$

where, t = thickness

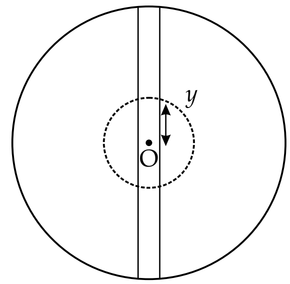
K = dielectric constant

Putting the given values, we get

$$C = \frac{\varepsilon_0(40\times10^{-4})}{\left[2-1\left(1-\frac{1}{5}\right)\right]\times10^{-3}} = \frac{4\varepsilon_0}{1+\frac{1}{5}}$$

$$= \frac{10\varepsilon_0}{3}(\text{F})$$

17. Option (4) is correct.



Let the particle of mass m be at a distance y from the centre (mean position) at any instant Restoring force

$$F = {}^{-}mE_g = {}^{-}m\left(\frac{GMY}{R^3}\right) = m\frac{d^2y}{dt^2}$$

$$\frac{d^2y}{dt^2} = -\left(\frac{GM}{R^3}\right)y = -\omega^2 y \quad \text{(SHM proved)}$$

Comparing we get, $\omega = \sqrt{\frac{GM}{R^3}} = \frac{2\pi}{T}$

$$T = 2\pi\sqrt{\frac{R^3}{GM}} = 2\pi\sqrt{\frac{R^3}{gR^2}} = 2\pi\sqrt{\frac{R}{g}}$$

Putting for R and g we get, $T = 2\pi\sqrt{\frac{6400\times10^3}{10}}$

$$= 2\pi \times 8\times10^2$$

$$= \frac{1600\pi}{60}(\text{min})$$

$$= 84 \text{ min}$$

$$= 1 \text{ hour } 24 \text{ minutes}$$

18. Option (3) is correct.

For electrons, $\lambda = \frac{12.27}{\sqrt{V}}(\text{A})$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}}$$

$$\frac{\lambda_0}{\lambda_2} = \sqrt{\frac{40}{20}} \Rightarrow \lambda_2 = \frac{\lambda_0}{\sqrt{2}}$$

19. Option (3) is correct.

Efficiency of a Carnot engine is given by, $\eta = 1 - \frac{T_2}{T_1}$

in the first case $0.5 = 1 - \frac{T_2}{600}$

Here T_1 = temperature of the source

T_2 = temperature of the sink

$$\frac{T_2}{600} = 0.5$$

$$T_2 = 300 \text{ K}$$

In the second case $0.7 = 1 - \frac{300}{T_1'}$

$$\frac{300}{T_1'} = 0.3$$

$$T_1' = 1000 \text{ K}$$

20. Option (2) is correct.

Value of g' at a height h above the earth's surface is given by $g' = g\frac{R^2}{(R+h)^2}$

Since $h = R$, $g' = \frac{g}{4}$

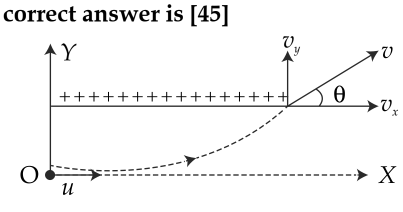
Now $T = 2\pi\sqrt{\frac{l}{g}}$ (on the earth's surface)

$T' = xT = 2\pi\sqrt{\frac{l}{g/4}} = 2T$ (at a height h)

Hence, $x = 2$

Section B

21. The correct answer is [45]



Let u be the initial speed

$$\text{KE} = 0.5 \text{ eV} = 0.5 \times 1.6 \times 10^{-19} = \frac{1}{2}mu^2$$

$$u = \sqrt{\frac{1.6\times10^{-19}}{m}}$$

Time taken before enticing the field, $t = \frac{l}{u}$

$v_x = u_x$ as $a_x = 0$

$v\cos\theta = u$ ....(i)

$v_y = u_y + a_y t$

since $u_y = 0$

$v_y = v\sin\theta = \frac{eE}{m}t$

$\therefore$ $v\sin\theta = \frac{eE}{m}\left(\frac{l}{u}\right)$ ....(ii)

From (i) and (ii) on diving, we get

$$\tan\theta = \frac{eE}{m}\frac{l}{u^2} = \frac{eE}{m}\frac{l}{(e/m)}$$

$= El$

$= 10\times01 = 1$

$\theta = 45°$

22. The correct answer is [27]

2nd Excited state corresponds to $h = 3$ and

1st Excited elate corresponds to $n = 2$

$$\frac{1}{\lambda_0} = R\left(\frac{1}{4}-\frac{1}{9}\right) = \frac{5R}{36} \quad \text{...(i)}$$

Similarly 3rd excited state corresponds to $n = 4$

$$\frac{1}{\lambda_0} = \frac{x}{20\lambda_0} = R\left(\frac{1}{4}-\frac{1}{16}\right) = \frac{3R}{16} \quad \text{...(ii)}$$

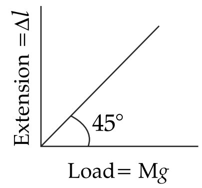
Dividing eq. (i) by (ii),

$$\frac{20}{x} = \frac{5}{36}\times\frac{144}{7} = \frac{20}{7}$$

$$\frac{20}{x} = \frac{5}{36}\times\frac{16}{3} = \frac{20}{27}$$

$x = 27$

23. The correct answer is [5]



From the graph $\Delta l = Mg$

Young's Modulus, $Y = \frac{F/A}{\Delta l/l} = \frac{Mg}{A}\times\frac{l}{\Delta l} = \frac{l}{A}$

$$Y = \frac{62.8\times10^{-2}}{\frac{\pi}{4}\times16\times10^{-6}}$$

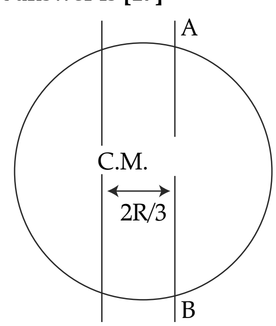
$$= \frac{62.8\times4}{3.14\times16}\times10^4$$

$Y = 5\times10^4$

Given, $Y = x\times10^4$

On comparing, $x = 5$

24. The correct answer is [17]



For a disc, $I_{CM} = \frac{MR^2}{2}$

$$I_{AB} = I_{CM} + M\left(\frac{2R}{3}\right)^2$$

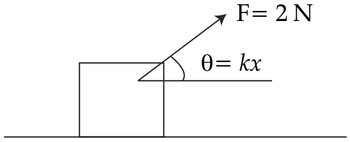
$$= \frac{MR^2}{2} + M\left(\frac{4R^2}{9}\right)$$

$$= \frac{17MR^2}{18}$$

$$\frac{I_{AB}}{I_{CM}} = \frac{17\times2}{18} = \frac{17}{9} = \frac{x}{9} \quad \text{[Given]}$$

$\Rightarrow$ $x = 17$

25. The correct answer is [2]



At any instant $F\cos\theta = ma$

$$2\cos(kx) = m\left(v\frac{dv}{dx}\right)$$

$$vdv = \frac{2}{m}\cos kx dx$$

Integrating, we get

$$\int_0^v vdv = \frac{2}{m}\int_0^x \cos kx\, dx$$

$$\frac{v^2}{2} = \frac{2}{mk}\sin kx$$

$$\frac{1}{2}mv^2 = \frac{2}{k}\sin\theta = \frac{n}{k}\sin\theta$$

On comparison, $n = 2$

26. The correct answer is [100]

For maximum value of current series R-L-C Circuit should be in resonance

$$\omega_0^2 = 4\pi^2 f_0^2 = \frac{1}{LC}$$

$$L = \frac{1}{4\pi^2 f_0^2 C} = \frac{1}{4\times10\times4\times10^6\times62.5\times10^{-9}}$$

$$= \frac{100}{16\times62.5}\ (\text{H})$$

$= 100$ (mH)

27. The correct answer is [18]

Given path difference = 6 m and

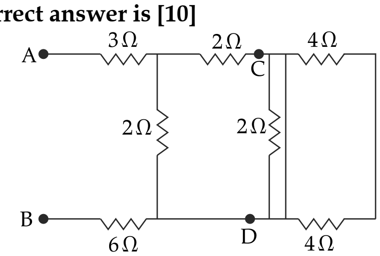
phase difference between the points = 60 = $\frac{\text{À}}{3}$

$$\Delta\phi = \frac{2\text{À}}{\text{À}}\Delta x$$

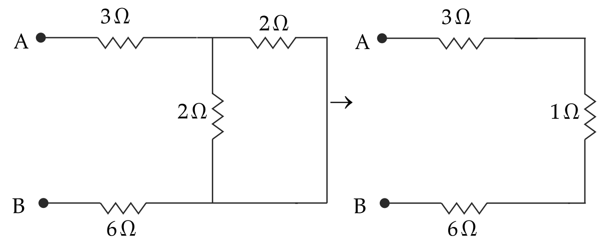
$$\lambda = \frac{2\pi\Delta x}{\Delta\phi} = \frac{2\pi\times6}{\frac{\pi}{3}} = 36\text{ m}$$

$$v = f\lambda = 500\times36 = 18000\text{ m/s} = 18\text{ km/s}$$

28. The correct answer is [10]



All the resistances to the light of the terminals C and D are shorted due to the connecting wire as shown. The remaining circuit can be redrawn As



$$R_{AB} = 3 + 6 + 1 = 10\ \Omega$$

29. The correct answer is [4]

$$\vec{P} = 3\hat{i} + \sqrt{3}\hat{j} + 2\hat{k}$$

$$\vec{Q} = 4\hat{i} + \sqrt{3}\hat{j} + 2.5\hat{k}$$

$$\vec{P}\times\vec{Q} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & \sqrt{3} & 2 \\ 4 & \sqrt{3} & 2.5 \end{vmatrix}$$

$$= \hat{i}\left(2.5\sqrt{3} - 2\sqrt{3}\right) - \hat{j}(7.5 - 8) + \hat{k}\left(3\sqrt{3} - 4\sqrt{3}\right)$$

$$= 0.5\sqrt{3}\hat{i} + 0.5\hat{j} - \sqrt{3}\hat{k}$$

$$\vec{P}\times\vec{Q} = \frac{1}{2}\left[\sqrt{3}\hat{i} + \hat{j} - 2\sqrt{3}\hat{k}\right]$$

Unit vector in the direction of $\vec{P}\times\vec{Q}$ is given by

$$\frac{\vec{P}\times\vec{Q}}{\left|\vec{P}\times\vec{Q}\right|} = \frac{\frac{1}{2}\left[\sqrt{3}\hat{i} + \hat{j} - 2\sqrt{3}\hat{k}\right]}{\frac{1}{2}\sqrt{3+1+12}} = \frac{1}{4}\left(\sqrt{3}\hat{i} + \hat{j} - 2\sqrt{3}\hat{k}\right)$$

$$= \frac{1}{x}\left(\sqrt{3}\hat{i} + \hat{j} - 2\sqrt{3}\hat{k}\right)$$

On comparing, we get $x = 4$

30. The correct answer is [52]

$$l_c = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45°$$

Snell's law gives

$$\sin i = \mu \sin r$$

$$\sin r = \frac{\sin i}{\mu} = \frac{1/\sqrt{2}}{\sqrt{2}} = \frac{1}{2}$$

$$r = \frac{\pi}{6} = 30°$$

Lateral displacement, $d = \dfrac{t\sin(i - r)}{\cos r}$

$$= \frac{\sqrt{3}\sin(45° - 30°)}{\cos 30°}$$

$$= \frac{\sqrt{3}\sin(15°)}{\cos 30°}$$

$$= \frac{\sqrt{3}\times0.26}{\sqrt{3}/2}$$

$= 0.52$ cm

$= 52\times10^{-2}$ cm

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